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TREATABILITY OF PUERTO RICAN WOODS

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FOREST SERVICE
U.S. DEPARTMENT OF AGRICULTURE

RESUMEN

Un ensayo de discos, sencillo pero altamente sensitivo, fue usado para clasificar los tratamientos de preservación de las maderas más comunes de Puerto Rico y las Islas Vírgenes. La albura se evaluó solamente para reflejar el gran número de árboles de diámetro pequeño disponibles para espeques y postes pequeños.

La absorción de los discos fluctuó entre menos de una y cerca de 40 libras por pie cúbico. La absorción de aceite en los discos recubiertos y los no recubiertos puede relacionarse con la absorción de los postes con y sin incisiones que han sido tratados en un sistema de baño caliente y frío. Se pronosticó que de las 53 especies de postes sin incisiones evaluadas, solamente seis obtendrían un tratamiento adecuado (6-12 libras por pie cúbico). De tener incisiones los postes, 32 especies tendrían una retención aceptable. Se pueden anticipar resultados similares para las sales preservativas solubles en agua. La información obtenida de algunas especies indicaba que la absorción de discos no recubiertos podría ser usada también para predecir la retención de los postes tratados en un proceso de alta presión en célula vacía.

ABSTRACT

A simple but highly sensitive wafer assay was used to classify the treatability of the more common woods of Puerto Rico and the Virgin Islands. Sapwood only was tested to reflect the large number of small diameter trees available for posts and short poles.

Wafer absorptions ranged from less than 1 to about 40 lb./cu. ft. Oil absorption of coated and uncoated wafers can be related to the absorption of non-incised and incised posts treated in a hot-and-cold bath system. For non-incised posts, only 6 out of the 53 species evaluated were predicted to obtain an adequate treatment (6-12 lb./cu. ft.). If incised, 32 species would have an acceptable retention. Similar results may be anticipated for water-borne preserving salts. Data from a few species indicated that absorption of uncoated wafers could also be used to predict retention of posts treated by a high pressure empty-cell process.

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TREATABILITY OF PUERTO RICAN WOODS

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INTRODUCTION

Wood products are vulnerable to insect and fungus attack, particularly in the humid tropics. For many uses, impregnation with preservatives would be of value. Unfortunately, not all timbers are equally receptive to such treatments. Species treatability may be detected by laboratory permeability studies (6), in pilot plant experiments (1,3,5), or in actual commercial operations (4). Such classifications of treatability are helpful not only in the application of preservatives, but also in the application of fire retardants, anti-shrink chemicals, water repellents, and other modifying agents.

A wafer assay technique for determining treatability of wood has been described (2). Reliable species differentation is possible without expensive pressure-vacuum systems or elaborate laboratory liquid-gas flow instrumentation.

Based on this wafer assay method, the treatability of some 50 native and exotic woods common to Puerto Rico and the nearby Virgin Islands is reported here. Values are in terms of oil or water retentions in lb./cu. ft., and reflect either side grain penetration only (edge-coated) or a combined end and side grain flow (uncoated).

WAFER ASSAY METHOD

Material

Species assayed are listed in Table 1 in alphabetical order. With a few exceptions, five trees per species were sampled. Present major use potential is for posts and small poles, so only sapwood of small-diameter trees (3-5 in. dbh) was tested. To accelerate drying prior to wafer preparation, short bolts were debarked and sawn lengthwise to yield three billets.

Preparation of wafers

The steps followed in preparation of test wafers are as previously described (2) and are illustrated in Figure 1. Several tools were tried for cutting the plugs. The prong type is particularly effective with high density species. Four wafers were prepared for each of the trees sampled. Two were edge-coated with two coats of brushable epoxy paste to seal end grain and the other two were not coated. The side to end grain ratio of the wafers is approximately 2 to 1.

1/ In cooperation with the University of Puerto Rico

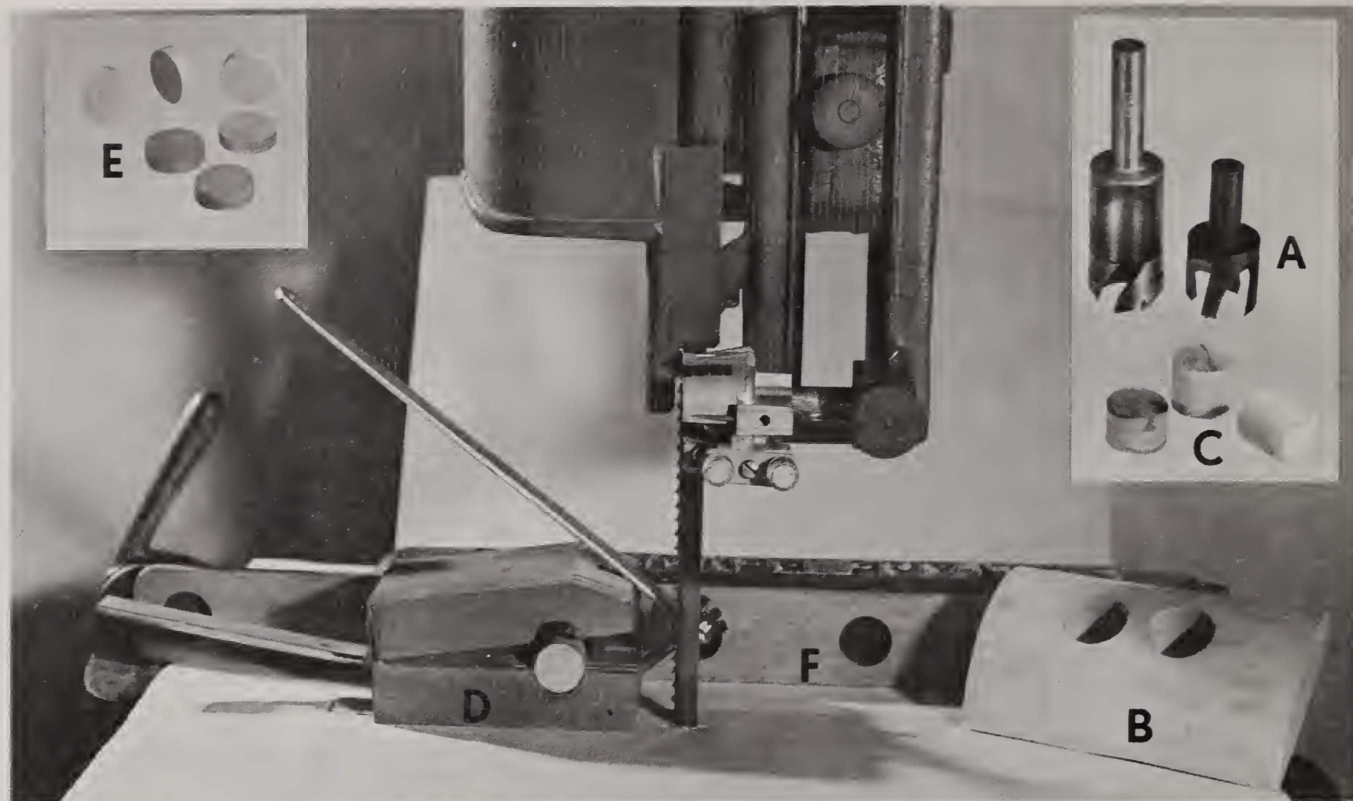

Figure 1. – Steps in the preparation of wafers from test billets. The plug cutter (A) was mounted in a drill press and fed into the air-dried billet (B) in a radial direction towards the pith. The plugs (C) were 7/8 inch in diameter and about 1 inch in length. The plugs were held in the squeeze clamp (D) and cut into wafers (E) using a four tooth-to-the-inch band saw. Sapwood wafers only were used in this study and were removed from the second 0.25-inch zone beneath the cambium. To accurately obtain this thickness, a removable fence (F) was inserted against the fixed fence.

Wafer treatments

Wafer diameters and thicknesses were measured with a vernier caliper to 0.1 mm and volumes calculated. Weights to the nearest 0.01 g were determined before and after edge coating. Wafers were submerged in water or diesel oil bath (70°F) in a vacuum desiccator and held under a vacuum of about 30 in. of mercury for 10 minutes. The desiccator was then vented to atmospheric pressure. Wafers were kept submerged for an additional 10 minutes. The treating solution was then drained off, the wafers blotted to remove surface liquid, and reweighed. Oil or water retention in lb./cu. ft. was then calculated. Also calculated were the air-dry specific gravities based on weight and volume at the test moisture content of 12 percent.

RESULTS

Table 1 lists the oil and water absorptions for edge-coated and uncoated wafers. The air-dry specific gravities are also given. Liquid retentions range from less than 1 lb. to about 40 lb./cu. ft. For almost all species, the uncoated wafers (combined end and side grain penetration) have retentions substantially higher than that for the edge-coated material (side penetration only). Differences are slight only in the highly permeable species; i.e., kadam, pino, achiotillo, manzanillo, corcho. Within species, variability in wafer absorption is least for the uncoated specimens. The coefficient of variation averages about 15 percent as compared to 30 percent for edge-coated wafers. All of the high absorption species have an air-dry (12 percent moisture content) specific gravity of 0.65 or less. However, within this density group there is an equal number of species with very low absorptions. With only a few exceptions, water absorptions are much higher than oil absorptions. This may be accounted for by differences in viscosity and the availability of interfibril spaces to water movement.

In the earlier study (2), a comparison was made between oil absorption of incised and non-incised posts and the oil absorption of uncoated and edge-coated wafers. Posts were treated by a 2 hour - 2 hour hot-and-cold bath schedule and wafers were treated as described above. Eighteen species were matched. It was determined that uncoated wafer absorptions simulate that of the incised posts ($Y = 1.21 + 0.89X$) and absorptions of coated wafers simulate those of non-incised posts ($Y = 0.35 + 1.14X$). In both regressions, correlation coefficients (r) were about 0.9.

The oil retentions, then, of the species listed in Table 1, not only indicate relative permeability or treatability but, also, levels of absorption likely to be obtained in a hot-and-cold bath preservation system. Table 2 presents a classification of treatability in oil of non-incised posts given a 2 hour - 2 hour thermal bath and is based on the edge-coated wafer assay. We have assumed an oil absorption of less than 6 lb./cu. ft. as inadequate, a range of 6 to 12 lb./cu. ft. as acceptable, and absorption over 12 lb./cu. ft. as excessive. Of the 53 species tested, 41 are predicted to have inadequate absorptions, 6 to have acceptable absorptions, and 6 to have an excessive uptake.

Predictions of treatability in oil of incised posts, based on the non-coated wafer assay, are given in Table 3. For the same 53 species, 32 have acceptable absorptions, 12 undertreat, and 9 overtreat. Of the 12 poor absorbers, only quenepa and zarcilla have retentions less than 5 lb./cu. ft. The advantage of incising for treating mixed lots of tropical woods is evident.

Water retentions given in Table 1 are somewhat difficult to interpret in terms of absorption of preserving salts. Generally, these water-borne chemicals are applied by a full-cell process using concentrations of 2-3 percent. If we assume a boiling-in-water thermal process where the salt solution is held in the cold tank only, and if we specify a minimum dry salt retention of 0.45 lb./cu. ft., then we could predict treatability as shown in Table 4. Less than one-half of the 53 species would have acceptable absorptions if incised posts were to be treated with a 3.0 percent preservative salt concentration. This would mean a solution retention of 15 to 30 lb./cu. ft. or 0.45 to 0.90 lb./cu. ft. dry salt residual. If posts were not incised only four species would be receptive to this thermal treatment and they are achiotillo, almácigo, corcho, and manzanillo. Kadam and pino absorptions would be excessive; i.e., over 30 lb./cu. ft. solution retention. Treatment levels of these two plantation species can be reduced by lowering the bath concentration to 2.0 percent.

There is very limited data on the response of these woods to a pressure-vacuum preservative treatment. Twelve of the species listed in Table 1 have been treated with a petroleum oil carrier using 2 hours of pressure at 150 psi followed by a one-half-hour vacuum at 27 in. of mercury. Non-incised all-sapwood posts were used. There is also some retention data for 5 additional species treated for 3 hours at 125 psi followed by a 1 hour vacuum period. In both cases preservative temperature was ambient.

A simple regression based on the absorption of the pressure-treated posts and non-coated wafer assays of the same species is significant at the 0.01 level. The correlation coefficient is about 0.91. Post absorptions are predicted by: $Y = 0.99 + 0.88X$. Thus, not only are the relative order of treatablility of posts and wafers about the same, but absorptions pound for pound are also of about the same magnitude. These tests indicate that longitudinal penetration from the ends of non-incised posts is a significant preservative flow path when treating under high pressure.

Table 1.--WAFER ASSAYS OF TREATABILITY IN OIL AND WATER OF COMMON WOODS OF PUERTO RICO BASED ON A 10 MINUTE VACUUM--10 MINUTE ATMOSPHERIC PRESSURE SCHEDULE.

Common Name 1/	Scientific Name	Air-dry 2/ Specific Gravity	Oil Retention Edge-Coated (lb./cu. ft.)	Oil Retention Uncoated (lb./cu. ft.)	Water Retention Edge-Coated (lb./cu. ft.)	Water Retention Uncoated (lb./cu. ft.)
Achiotillo	*Alchornea latifolia* Sw.	.47	20.8	21.0	30.2	34.4
Algarrobo	*Hymenaea courbaril* L.	.92	5.8	8.9	4.0	14.2
Almácigo	*Bursera simaruba* (L.) Sarg.	.35	9.5	12.8	22.7	28.8
Almendra * 3/	*Terminalia catappa* L.	.53	3.2	6.2	4.1	14.6
Ausubo	*Manilkara bidentata* (A.DC.) Chev.	.96	1.1	5.1	2.7	11.6
Caimitillo 4/	*Micropholis chrysophylloides* Pierre	.87	8.0	12.1	-	18.7
Caimitillo verde 4/	*Micropholis garciniaefolia* Pierre	.93	5.8	10.8	5.2	16.2
Camasey 4/	*Miconia laevigata* (L.) DC.	.71	1.2	6.3	2.3	13.7
Caoba dominicana *	*Swietenia mahagoni* Jacq.	.76	1.6	5.2	4.9	13.6
Capá blanco	*Petitia domingensis* Jacq.	.81	0.9	6.0	2.0	10.4
Casia de Siam *	*Cassia siamea* Lam.	.85	1.6	5.2	2.6	10.6
Casuarina * 4/	*Casuarina equisetifolia* L.	.95	3.8	10.3	3.9	17.7
Corcho	*Torrubia fragrans* (Dum.-Cours.) Standley	.65	16.8	19.6	24.4	33.2
Espino rubial	*Zanthoxylum martinicense* (Lam.) DC.	.74	1.4	7.1	5.7	18.8
Eucalipto *	*Eucalyptus robusta* J.E. Smith	.57	6.2	9.7	4.5	23.4
Granadillo	*Buchenavia capitata* (Vahl.) Eichl.	.75	3.2	9.6	3.9	11.8
Guaba	*Inga vera* Willd.	.66	3.5	7.6	4.1	10.1
Guamá	*Inga laurina* (Sw.) Willd.	.79	2.0	6.7	4.9	12.3
Guara	*Cupania americana* L.	.81	1.6	7.1	2.3	14.0
Guaraguao	*Guarea trichilioides* L.	.63	1.9	6.6	2.6	13.7
Hoja menuda	*Myrcia splendens* (Sw.) DC.	.79	5.1	10.7	4.7	15.4
Jaguey blanco	*Ficus laevigata* Vahl.	.55	2.4	5.1	5.6	12.3
Kadam *	*Anthocephalus cadamba* (Roxb.) Miq.	.37	27.4	28.7	34.7	40.7
Laurel avispillo	*Nectandra coriacea* (Sw.) Griseb.	.90	1.8	7.0	2.6	15.5
Mangle blanco	*Laguncularia racemosa* (L.) Gaertn. f.	.74	1.1	4.7	2.6	11.6

1/ Species are listed in alphabetical order.
2/ Based on weight and volume at 12 percent moisture content.
3/ Exotics are marked with an asterisk.
4/ Less than five trees sampled.

Table 1.--WAFERS ASSAYS OF TREATABILITY IN OIL AND WATER OF COMMON WOODS OF PUERTO RICO BASED ON A 10 MINUTE VACUUM--10 MINUTE ATMOSPHERIC PRESSURE SCHEDULE. (Continued)

Common Name 1/	Scientific Name	Air-dry 2/ Specific Gravity	Oil Retention Edge-Coated (lb./cu. ft.)	Oil Retention Uncoated (lb./cu. ft.)	Water Retention Edge-Coated (lb./cu. ft.)	Water Retention Uncoated (lb./cu. ft.)
Mangle colorado	*Rhizophora mangle* L.	1.01	0.9	4.8	2.8	13.1
Mangle prieto	*Avicennia nitida* Jacq.	.90	2.4	6.8	4.3	20.3
Mantequero	*Rapanea ferruginea* (Ruiz & Pav.) Mez.	.75	1.0	8.6	4.9	19.6
Manzanillo	*Sapium laurocerasus* Desf.	.58	19.6	19.7	26.2	28.5
María	*Calophyllum brasiliense* Camb.	.70	4.0	12.5	3.1	18.1
Maricao	*Byrsonima coriacea* (Sw.) DC.	.79	2.5	11.0	3.5	19.2
Moca	*Andira inermis* (W. Wright) H.B.K.	.87	1.9	5.4	3.4	11.0
Moral	*Cordia sulcata* DC.	.57	4.8	11.0	5.1	19.4
Motillo 4/	*Sloanea berteriana* Choisy	.97	4.3	7.4	2.1	11.5
Palo blanco	*Casearia guianensis* (Aubl.) Urban	.72	3.4	11.6	4.1	21.0
Palo de cucubano	*Guettarda scabra* (L.) Vent.	.78	1.6	7.7	2.0	14.8
Palo de matos 4/	*Ormosia krugii* Urban	.58	2.1	12.7	9.1	21.3
Péndula	*Citharexylum fruticosum* L.	.81	0.9	7.4	2.2	14.4
Pino *	*Pinus caribaea* Morelet	.47	31.9	32.8	42.2	43.0
Pomarrosa *	*Eugenia jambos* L.	.87	1.7	6.3	3.2	17.3
Quenepa *	*Melicoccus bijugatus* Jacq.	.78	1.3	3.5	5.3	13.7
Rabo ratón	*Casearia arborea* (L.C. Rich.) Urban	.76	1.7	9.0	3.6	21.2
Roble blanco	*Tabebuia heterophylla* (DC.) Britton	.69	2.9	8.2	5.0	17.8
San José	*Sabinea florida* (Vahl.) DC.	.89	1.3	5.0	1.9	9.9
Tabonuco	*Dacryodes excelsa* Vahl.	.62	2.3	6.9	4.3	15.9
Teca *	*Tectona grandis* L. f.	.70	1.2	5.1	2.5	12.7
Tulipán africano *	*Spathodea campanulata* Beauv.	.43	11.4	23.6	9.5	22.0
Ucar	*Bucida buceras* L.	1.08	1.1	5.9	2.2	9.9
Uvilla	*Coccoloba diversifolia* Jacq.	.90	1.5	5.3	3.1	11.4
Verdiseco	*Tetrazygia elaeagnoides* (Sw.) DC.	.84	1.3	6.6	3.1	14.4
Yagrumo hembra	*Cecropia peltata* L.	.32	5.5	17.0	3.2	13.3
Yagrumo macho	*Didymopanax morototoni* (Aubl.) Dec. & Planch.	.42	4.8	9.8	6.9	23.2
Zarcilla	*Leucaena glauca* (L.) Benth.	.93	0.5	2.1	2.0	4.2

1/ Species are listed in alphabetical order.

2/ Based on weight and volume at 12 percent moisture content.

3/ Exotics are marked with an asterisk.

4/ Less than five trees sampled.

Table 2. -- CLASSIFICATION OF TREATABILITY[1/] IN OIL OF NON-INCISED POSTS PREDICTED BY EDGE-COATED WAFER ASSAYS.

Inadequate Absorption - less than 6 lb. per. cu. ft.

almendra	guara	maricao	rabo ratón
ausubo	guaraguao	moca	roble blanco
camasey	hoja menuda	moral	San José
caoba dominicana	jaguey blanco	motillo	tabonuco
capá blanco	laurel avispillo	palo blanco	teca
casia de Siam	mangle blanco	palo de cucubano	ucar
casuarina	mangle colorado	palo de matos	uvilla
espino rubial	mangle prieto	péndula	verdiseco
granadillo	monteguero	pomarrosa	yagrumo macho
guaba	maría	quenepa	zarcilla
guamá			

Acceptable Absorption - 6 to 12 lb. per cu. ft.

algarrobo	caimitillo	eucalipto
almácigo	caimitillo verde	yagrumo hembra

Excessive Absorption - over 12 lb. per cu. ft.

achiotillo	kadam	pino
corcho	manzanillo	tulipán africano

1/ Assuming a 2 hr. - 2 hr. hot-and-cold bath schedule.

Table 3. -- CLASSIFICATION OF TREATABILITY[1/] IN OIL OF INCISED POSTS PREDICTED BY UNCOATED WAFER ASSAYS

Inadequate Absorption - less than 6 lb. per cu. ft.

ausubo	mangle blanco	San José
caoba dominicana	mangle colorado	teca
casia de Siam	moca	uvilla
jaguey blanco	quenepa	zarcilla

Acceptable Absorption - 6 to 12 lb. per cu. ft.

algarrobo	eucalipto	mangle prieto	péndula
almendra	granadillo	monteguera	pomarrosa
caimitillo	guaba	maría	rabo ratón
caimitillo verde	guamá	maricao	roble blanco
camasey	guara	moral	tabonuco
capá blanco	guaraguao	motillo	ucar
casuarina	hoja menuda	palo blanco	verdiseco
espino rubial	laurel avispillo	palo de cucubano	yagrumo macho

Excessive Absorption - over 12 lb. per cu. ft.

achiotillo	kadam	pino
almácigo	manzanillo	tulipán africano
corcho	palo de matos	yagrumo hembra

1/ Assuming a 2 hr. - 2 hr. hot-and-cold bath schedule.

Table 4. -- CLASSIFICATION OF TREATABILITY IN WATER OF INCISED POSTS PREDICTED BY UNCOATED WAFER ASSAYS

Inadequate Absorption - less than 15 lb. per cu. ft.[1]

algarrobo	guaba	mangle colorado	teca
ausubo	guamá	moca	ucar
camasey	guara	motillo	uvilla
caoba dominicana	guaraguao	péndula	verdiseco
capá blanco	jaguey blanco	quenepa	yagrumo hembra
casia de Siam	mangle blanco	San José	zarcilla
granadillo			

Acceptable Absorption - 15 to 30 lb. per cu. ft.

almacigo	mangle prieto	palo de matos
almendra	monteguero	pomarroso
caimitillo	manzanillo	rabo ratón
caimitillo verde	maría	roble blanco
casuarina	maricao	tabonuco
espino rubial	moral	tulipán africano
eucalipto	palo blanco	yagrumo macho
hoja menuda	palo de cucubano	
laurel avispillo		

Excessive Absorption - over 30 lb. per cu. ft.

achiotillo	
corcho	kadam
	pino

[1] Based on a treating solution salt concentration of 3.0 percent and a minimum dry salt retention of 0.45 lb. per cu. ft.

CONCLUSIONS

A simple but highly sensitive wafer assay is used to classify the treatability of the more common woods of Puerto Rico and the Virgin Islands. Conclusions are as follows:

1. For the 53 species tested, sapwood wafer absorptions ranged from less than 1 to about 40 lb./cu. ft.

2. Within species, variability in absorption is least for non-coated wafers (combined end and side grain penetration). The coefficient of variation averages about 15 percent as compared to an average of 30 percent for edge-coated wafers (side grain penetration only).

3. Generally, water absorptions are much higher than oil absorptions.

4. Oil absorptions of coated and uncoated wafers can be related to the absorption of non-incised and incised posts treated by a thermal process.

5. Without incising, only 6 of the 53 species can be treated adequately using oil in a hot-and-cold bath system. If incised, 32 species will have an acceptable absorption; i.e., 6-12 lb./cu. ft. Somewhat similar results may be anticipated if treatments are with water-borne salts.

6. A few preliminary tests indicate that absorptions of uncoated wafers can also be used to predict retentions of posts treated by a high pressure empty-cell process.

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